AD-A245 529

MENTATION PAGE

Form Approved
OMB No. 0704-0188

2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
1991	Reprint

4. TITLE AND SUBTITLE
(see title on reprint)

5. FUNDING NUMBERS
PE: NWED QAXM
WU: 00157

6. AUTHOR(S)
Kandasamy et al.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Armed Forces Radiobiology Research Institute
Bethesda, MD 20889-5145

8. PERFORMING ORGANIZATION REPORT NUMBER
SR91-47

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Defense Nuclear Agency
6801 Telegraph Road
Alexandria, VA 22310-3398

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

92-02494

92 1 31 016

14. SUBJECT TERMS

15. NUMBER OF PAGES
5

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED		

SECURITY CLASSIFICATION OF THIS PAGE

CLASSIFIED BY:

DECLASSIFY ON:

SECURITY CLASSIFICATION OF THIS PAGE

RADIATION RESEARCH 126, 218–222 (1991)

Role of Neurotensin in Radiation-Induced Hypothermia in Rats

SATHASIVA B. KANDASAMY, WALTER A. HUNT, AND ALAN H. HARRIS

Behavioral Sciences Department, Armed Forces Radiobiology Research Institute, Bethesda, Maryland 20814-5145

KANDASAMY, S. B., HUNT, W. A., AND HARRIS, A. H. Role of Neurotensin in Radiation-Induced Hypothermia in Rats. *Radiat. Res.* 126, 218–222 (1991).

The role of neurotensin in radiation-induced hypothermia was examined. Intracerebroventricular (ICV) administration of neurotensin produced dose-dependent hypothermia. Histamine appears to mediate neurotensin-induced hypothermia because the mast cell stabilizer disodium cromoglycate and antihistamines blocked the hypothermic effects of neurotensin. An ICV pretreatment with neurotensin antibody attenuated neurotensin-induced hypothermia, but did not attenuate radiation-induced hypothermia, suggesting that radiation-induced hypothermia was not mediated by neurotensin.

INTRODUCTION

Exposure to ionizing radiation causes changes in core body temperature. This effect depends partly upon the species of animal, with hyperthermia occurring in cats, rabbits (*1*), and humans (*2*), and a biphasic response (i.e., a fall in temperature followed by a rise) in monkeys (*3*). In rats, the direction of the temperature change is dose dependent with hyperthermia occurring when radiation doses are less than 15 Gy and hypothermia occurring when doses are greater than 20 Gy. In rats, the temperature response appears to be centrally mediated because irradiation of the head alone causes these effects, while irradiation of the trunk only does not (*4, 5*).

The chemical mediators identified thus far include prostaglandins (*5*) and histamine (*5*), while serotonin has been shown not to be involved (*4*). It is not known if histamine release is a primary response to irradiation or secondary to the release of other substances, such as neurotensin, liberated in the cascade of events following radiation injury.

Neurotensin, an endogenous tridecapeptide found in the central nervous system, particularly in hypothalamus, caudate nucleus, globus pallidus, putamen, nucleus accumbens and amygdala (*6–9*), and gastrointestinal tract (*10*), acts as a neurotransmitter or a neuromodulator (*11*). Specific neurotensin binding sites have been identified in the midbrain (*6, 12*), and interactions between neurotensin and dopamine have been shown (*13*). Central administration of neurotensin produces a variety of behavioral and physiological effects, including the stimulation of histamine release (*14*). One of the more potent effects of neurotensin is the induction of hypothermia after intracisternal or intraventricular administration (*15–17*). The purposes of this study were to investigate the role of neurotensin in radiation-induced hypothermia and to elucidate the mechanisms involved in neurotensin-induced hypothermia.

METHODS

Drugs. The drugs used were neurotensin (Sigma Chemical Co., St. Louis, MO), neurotensin antibody (Accurate Chemical and Scientific Corporation, Westbury, NY), disodium cromoglycate (Fisons Corporation, Bedford, MA), mepyramine maleate (Mallinckrodt Inc., St. Louis, MO), cimetidine (Smith Kline and French Laboratory, Philadelphia, PA), ketamine hydrochloride (Parke-Davis, Detroit, MI), xylazine (Hayer Lockhart, Shawnee, KS), and acepromazine (Ayerst Laboratories, NY). Neurotensin, neurotensin antibody, mepyramine, and disodium cromoglycate were dissolved in sterile, nonpyrogenic saline. Cimetidine was dissolved in 0.1 ml of 1 *N* HCl and diluted to the final volume with saline.

Animals. Male Sprague-Dawley Crl:CD(SD)BRD rats (Charles River Breeding Laboratories, Kingston, NY) weighing 200–300 g were used in these experiments. Rats were quarantined on arrival and screened for evidence of disease by serology and histopathology. The rats were housed individually in polycarbonate isolator cages (Lab Products, Maywood, NJ) on autoclaved hardwood contact bedding (Beta Chip, Northeastern Products Corp., Warrensburg, NY), and were provided commercial rodent chow (Wayne Rodent Blok, Continental Grain Co., Chicago, IL) and acidified water (pH 2.5 using HCl) *ad libitum*. Animal holding rooms were kept at 21 ± 1°C with 50 ± 10% relative humidity on a 12-h light/dark cycle with no twilight.

Radiation exposure. Rats were placed in clear plastic well-ventilated containers for approximately 5 min before irradiation or sham exposure. The animals were then exposed bilaterally to γ rays using a ^{60}Co source at a rate of 20 Gy/min to a total dose of 50 Gy. Prior to the experiment, the dose rate at the midline of an acrylic rat phantom was measured using a 0.5-cc tissue-equivalent ionization chamber manufactured by Exradin, Inc. The dose rate at the same location with the phantom removed was measured using a 50-cc ionization chamber fabricated at AFRRI. The ratio of these two dose rates, the tissue–air ratio, was used to determine the doses for animals receiving routine experimental exposures, in this experiment, the tissue–air ratio was 0.93. All ionization chambers have calibration factors traceable to the National Institute for Standards and Technology. Dosimetry measurements were performed following the AAPM Task Group 21 Protocol for the Determination of the Absorbed Dose from High-Energy Photon and Electron Beams (*18*).

0033-7587/91 $3.00

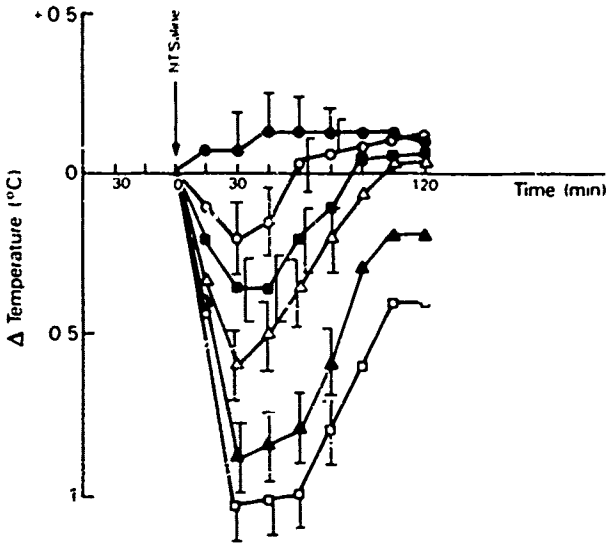

FIG. 1. Changes in rectal temperature of rats induced by intracerebroventricular (ICV) injection of neurotensin (NT): 1 μg (○), 3 μg (■), 5 μg (△), 10 μg (▲), 20 μg (□), and saline (●). Each point represents the mean ± SE of observations of five animals. Zero on the ordinate represents the temperature at the time of injection.

Central administration of drugs. Rats were anesthetized with 1 ml/kg of a mixture of ketamine (50 mg/kg), xylazine (5 mg/kg), and acepromazine (1 ml/kg) given intramuscularly, and were placed in a rat stereotaxic apparatus (David Kopf Instruments, No. 320). A single cannula was inserted aseptically into the lateral ventricle according to coordinates derived from the atlas of Pelligrino *et al.* (*19*): 0.8 mm posterior to bregma, 2.5 mm lateral. The cannula was lowered until cerebrospinal fluid rose in the cannula. Dental acrylic was used to secure the cannula. Animals were allowed to recover for 1 week before they were used for experiments. After the end of an experiment, injection sites were verified histologically. Injections and irradiations were performed at the same time of day (0900) to avoid diurnal variations in temperature. The antagonists (neurotensin antibody, disodium cromoglycate, mepyramine, and cimetidine) were given 30 min before the radiation and neurotensin were administered.

Measurement of body temperature. All experiments were performed at a room temperature of 22 ± 1°C. The animals were placed in restraining cages 1 h before starting the experiments, and body temperature was measured every 15 min for 2 h with thermistor probes (YSI series 700, Yellow Springs Co., Inc., Yellow Springs, OH) inserted approximately 6 cm into the rectum and connected to a datalogger (Minitrend 205). After each experiment, all animals were killed immediately with an overdose of carbon dioxide by inhalation.

Statistics. Statistical evaluations were performed using analysis of variance with a significance level of $P < 0.05$. Intergroup comparisons were made using Tukey's test (*20*).

RESULTS

An ICV administration of 1–20 μg of neurotensin induced hypothermia in a dose-dependent manner (Fig. 1). An ICV pretreatment with 0.25–1.0 mg of neurotensin antibody attenuated the hypothermia induced by ICV administration of 5 μg of neurotensin, but did not reduce the hypothermia produced by 50 Gy of ionizing radiation (Fig. 2). Figure 2 also shows that administration of neurotensin antibody alone had no effect on body temperature. An ICV administration of the mast cell stabilizer disodium cromoglycate did not change the body temperature of control animals but did block, in a dose-dependent manner, the hypothermia produced by the ICV injection of 5 μg neurotensin (Fig. 3). Mepyramine and cimetidine are specific H_1 and H_2 receptor antagonists, respectively (*21*). Mepyramine (100–300 ng, ICV) or cimetidine (100–300 ng, ICV) was administered before neurotensin to examine the role of histaminergic H_1 and H_2 receptors in neurotensin-induced hypothermia. Previous studies (*4, 5*) indicate that the same doses of mepyramine and cimetidine are specific H_1 and H_2 receptor antagonists, respectively, and did not change the body temperature in control animals. Both mepyramine and cimetidine, which are found to antagonize histamine-induced hypothermia (*4, 5*) attenuated neurotensin-induced hypothermia (Fig. 4).

DISCUSSION

Ionizing radiation induces either hyperthermia or hypothermia depending upon the dose; temperature changes appear to be centrally mediated (*4, 5*). Histamine has been implicated in the actions of ionizing radiation, including hypotension, reduced cerebral blood flow, and performance decrement (*22*). Furthermore, concentrations of histamine in circulating blood have been elevated in humans undergoing radiation therapy (*23*) as well as in dogs and monkeys (*24–26*) following radiation exposure. Histamine is present in a high concentration in the hypothalamus (*27, 28*), and is localized in nerve terminals (*29*), suggesting that it may act as a central neurotransmitter. Also, histamine is involved in many physiological functions, including thermoregulation, and could underlie radiation-induced hypothermia (*4, 5, 30*).

Histamine is stored in mast cells throughout the body (*31*), including the brain (*32, 33*), and neurotensin has been used to stimulate histamine release (*34–38*). When injected into the lateral cerebral ventricle, neurotensin induced a dose-dependent hypothermia in rats and mice (*15–17*), confirming previous results. Neurotensin is contained in the normal cerebrospinal fluid (*39, 40*), and may play a role in thermoregulation, because central administration of neurotensin decreases colonic temperature in rodents (*15–17*), but is ineffective following peripheral administration (*15*). In addition, Muraki *et al.* (*41*) reported a decrease in the level of neurotensin-like immunoreactivity in the cerebrospinal fluid of children with febrile aseptic meningitis,

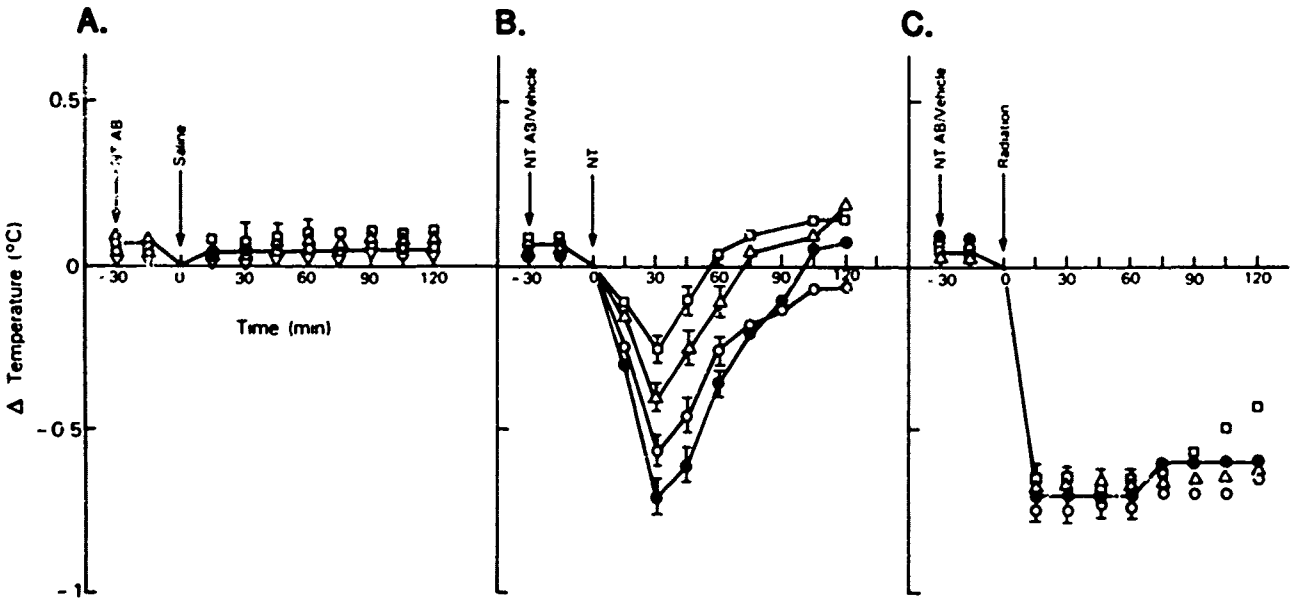

FIG. 2. Effect of neurotensin antibody (NT-AB), ICV, on NT-or radiation-induced hypothermia. (A) Nonirradiated controls given 25 μg (○), 50 μg (△), or 100 μg (□) NT-AB; (B) 5 μg of NT alone (●) or in the presence of 25 μg (○), 50 μg (△), or 100 μg (□) NT-AB; (C) 50 Gy irradiation alone (●) or in the presence of 25 μg (○), 50 μg (△), or 100 μg (□) NT-AB. Each point represents the mean ± SE of observations of five animals. Zero on the ordinate represents the temperature at the time of second injection.

suggesting an important role for neurotensin in thermoregulation.

Disodium cromoglycate is a potent inhibitor of the immunological release of chemical mediators secreted from mast cells (*21*). It has been reported that neurotensin stimulates the release of histamine *in vivo* (*37, 38, 42*), and pretreatment with disodium cromoglycate inhibits the neurotensin-induced release of histamine (*34, 36, 37, 43*). The attenuation of neurotensin-induced hypothermia by disodium cromoglycate and histamine H_1 and H_2 receptor antagonists in this study suggests that neurotensin-induced hypothermia was mediated by histamine.

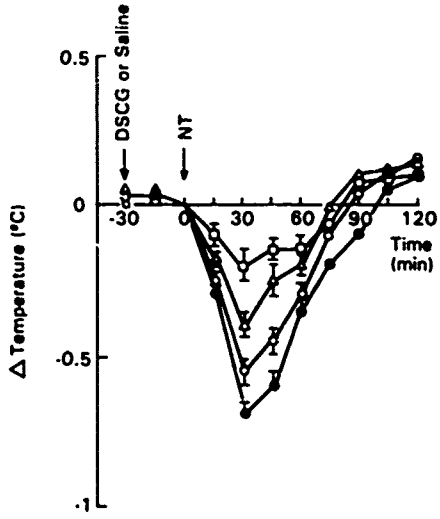

FIG. 3. Effect of disodium cromoglycate (DSCG), ICV, on NT-induced hypothermia. The 5 μg of NT alone (●) or in the presence of 100 ng (○), 300 ng (△), or 500 ng (□) DSCG. Each point represents the mean ± SE of observations of five animals. Zero on the ordinate represents the temperature at the time of second injection.

There are no specific antagonists available to antagonize neurotensin-induced hypothermia; therefore, specific antibodies to neurotensin were used to eliminate endogenous neurotensin, because they would bind and inactivate the neuropeptide (*43–45*). Researchers have reported that the centrally administered neurotensin antibody inhibits neurotensin-induced nociception and hypothermia (*44, 45*). In our experiments, pretreatment with neurotensin antibody attenuated neurotensin-induced hypothermia, but had no inhibitory effect on radiation-induced hypothermia, suggesting that neurotensin may not be involved in radiation-induced hypothermia. Although Cockerham *et al.* (*46*) found a nonsignificant increase in plasma neurotensin levels following exposure to ionizing radiation, because neurotensin is degraded rapidly, they think tissue levels might be significantly increased, causing the release of histamine from mast cells (*46*). In our study, pretreatment with neurotensin antibody, which attenuated neurotensin-induced hypothermia, did not reduce radiation-induced hypothermia.

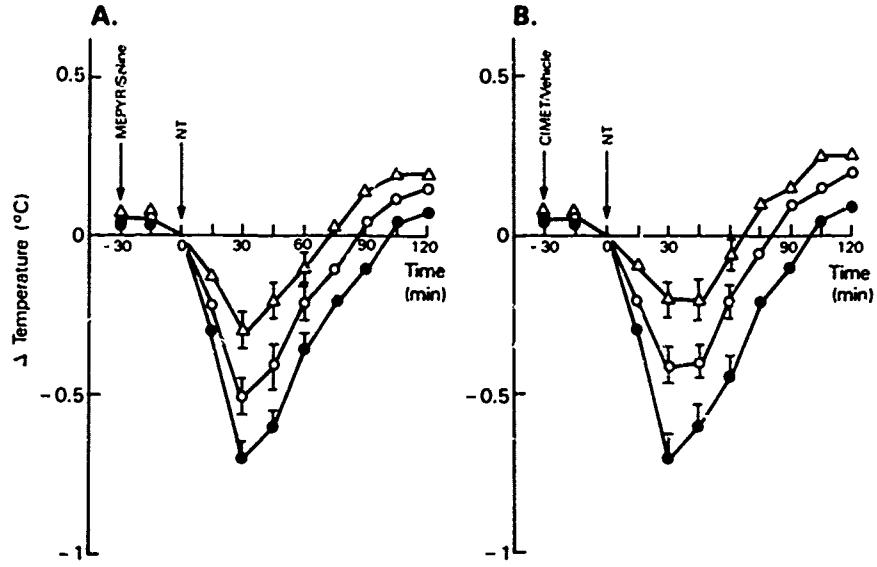

FIG. 4. Effect of mepyramine (MEPYR), ICV, or cimetidine (CIMET), ICV, on NT-induced hypothermia. (A) 5 μg of NT alone (●) or in the presence of 100 ng (○) or 300 ng (△) mepyramine. (B) 5 μg of NT alone (●) or in the presence of 100 ng (○) or 300 ng (△) cimetidine. Each point represents the mean ± SE of observations of five animals. Zero on the ordinate represents the temperature at the time of second injection.

Although neurotensin-induced hypothermia is mediated by histamine, we could not determine if radiation-induced hypothermia is mediated by endogenous neurotensin.

RECEIVED: April 26, 1990; ACCEPTED: December 13, 1990

REFERENCES

1. T. S. VENINGA, Implications of bioamines in the X-ray-induced temperature response of cats and rabbits. *Radiat. Res.* **48**, 358–367 (1971).
2. H. FANGER and C. C. LUSHBAUGH, Radiation death from cardiovascular shock following a criticality accident. *Arch. Pathol.* **84**, 446–460 (1967).
3. W. L. MCFARLAND and J. A. WILLIS, *Cerebral Temperature Changes in the Monkey (Macaca mulatta) after 2500 rads Ionizing Radiation*. Scientific Report SR 74-4, Armed Forces Radiobiology Research Institute, Bethesda, Maryland, 1974.
4. S. B. KANDASAMY, W. HUNT, and G. A. MICKLEY, Implication of prostaglandins and histamine H1 and H2 receptors in radiation-induced temperature responses of rats. *Radiat. Res.* **114**, 42–53 (1988).
5. S. B. KANDASAMY and W. A. HUNT, Involvement of prostaglandins and histamine in radiation-induced temperature responses in rats. *Radiat. Res.* **121**, 84–90 (1990).
6. G. R. UHL and S. H. SNYDER, Regional and subcellular distribution of brain neurotensin. *Life Sci.* **19**, 1827–1832 (1976).
7. G. R. UHL, M. J. KUHAR, and S. H. SNYDER, Neurotensin: Immunohistochemical localization in rat central nervous system. *Proc. Natl. Acad. Sci. USA* **74**, 4509–4053 (1977).
8. R. CARRAWAY and S. E. LEEMAN, Radioimmunoassay for neurotensin, a hypothalamic peptide. *J. Biol. Chem.* **251**, 7035–7044 (1976).
9. R. M. KOBAYASHI, M. BROWN, and W. VALE, Regional distribution of neurotensin and somatostatin in rat brain. *Brain Res.* **126**, 584–588 (1977).
10. R. E. CARRAWAY and S. E. LEEMAN, Characterization of radioimmunoassayable neurotensin in the rat: Its differential distribution in the central nervous system, small intestine and stomach. *J. Biol. Chem.* **251**, 7045–7052 (1976).
11. D. R. BROWN and R. G. MILLER, Neurotensin. *Br. Med. Bull.* **38**, 239–245 (1982).
12. G. R. UHL, R. R. GOODMAN, and S. H. SYNDER, Neurotensin-containing cell bodies, fibers, and nerve terminals in the brain stem of the rat. *Brain Res.* **167**, 77–91 (1979).
13. D. R. HAUBRICH, G. E. MARTIN, B. PFLUEGER, and M. WILLIAMS, Neurotensin effects on brain dopaminergic systems. *Brain Res.* **321**, 216–221 (1982).
14. S. A. ST PIERRE, R. KEROUAC, R. QUIRION, F. B. JOLICOEUR, and F. RIOUX, Neurotensin. *Pept. Protein Rev.* **2**, 83–171 (1984).
15. G. BISSETTE, C. B. NEMEROFF, P. T. LOOSEN, A. J. PRANGE, and M. A. LIPTON, Hypothermia and cold intolerance induced by the intracisternal administration of hypothalamic peptide neurotensin. *Nature* **262**, 607–609 (1976).
16. C. B. NEMEROFF, G. BISSETTE, A. J. PRANGE, P. T. LOOSEN, and M. A. LIPTON, Neurotensin: Central nervous system effects of a hypothalamic peptide. *Brain Res.* **128**, 485–498 (1977).
17. G. A. MASON, C. B. NEMEROFF, D. LUTTINGER, O. L. HATLEY, and A. J. PRANGE, Neurotensin and bombesin: Differential effects on body temperature of mice after intracisternal administration. *Regul. Pep.* **1**, 53–60 (1980).
18. Task Group 21, Radiation Therapy Committee AAPM, A protocol for the determination of absorbed dose from high energy photon and electron beams. *Med. Phys.* **10**, 741 (1983).
19. L. S. PELLIGRINO, A. S. PELLIGRINO, and A. J. CUSHMAN, *A Stereotaxic Atlas of the Rat Brain*. Plenum, New York, 1979.

20 G. V. GLASS and J. C. STANLEY, In *Statistical Methods in Education and Psychology*. Prentice-Hall, Englewood Cliffs, NJ, 1970.

21. A. GOTH. In *Medical Pharmacology*, 11th ed. C. V Mosby, St. Louis, MO, 1984.

22. T. F. DOYLE, J. E. TURNS, and T. A. STRIKE, Effect of an antihistamine on early transient incapacitation on monkeys subjected to 4 rads of mixed gamma-neutron radiation. *Aerospace Med.* **42**, 400–403 (1971).

23. E. C. LASSER and K. W. STENSTROM, Elevation of circulating blood histamine in patients undergoing deep roentgen therapy. *Am. J. Roentgenol.* **72**, 985–988 (1954).

24 T. F. DOYLE and T. A. STRIKE, Radiation-released histamine in the rhesus monkey as modified by mast cell depletion and antihistamine. *Experientia* **33**, 1047–1048 (1977).

25. L. G. COCKERHAM, T. F. DOYLE, M. A. DONLON, and E. A. HELGESON, Canine post-radiation histamine levels and subsequent response to compound 48/80. *Aviat. Space Environ. Med.* **55**, 1041–1045 (1984).

26. L. G. COCKERHAM, T. F. DOYLE, M. A. DONLON, and C. J. GOSSETT-HAGERMAN, Antihistamines block radiation-induced intestinal blood flow in canines. *Fundam. Appl. Toxicol.* **5**, 597–604 (1985).

27. H. M. ADAMS and H. K. A. HYE, Concentration of histamine in different parts of the cat and its modification by drugs. *Br. J. Pharmacol.* **28**, 137–152 (1966).

28. J. F. LIPINSKI, H. SCHAUMBURG, and R. J. BALDESSARINI, Regional distribution of histamine in human brain. *Brain Res.* **52**, 403–408 (1973).

29. S. H. SNYDER and K. M. TAYLOR, Histamine in the brain: A neurotransmitter. In *Perspectives in Neuropharmacology* (S. H. Synder, Ed.), pp. 43–73. Oxford Univ. Press, New York, 1972.

30. S. B. KANDASAMY and W. A. HUNT, Involvement of histamine H_1 and H_2 receptors in hypothermia induced by ionizing radiation in guinea pigs. *Life Sci.* **42**, 555–563 (1988).

31. D. D. METCALF, M. KALINER, and M. A. DONLON, In *CRC Critical Reviews in Immunology* (M. Z. Atassi, Ed.), pp. 23–74. CRC Press, Boca Raton, FL, 1981.

32 L. EDVINSSON, J. CERVOS-NAVARRP, L. LARRSON, C. H. OWMAN, and A. L. RONTBERG, Regional distribution of mast cells containing histamine, dopamine, or 5-hydroxytryptamine in the mammalian brain. *Neurology* **27**, 878–883 (1977).

33. P. M. GROSS, Cerebral histamine: Indications for neuronal and vascular regulation. *J. Cereb. Blood Flow Metabol.* **2**, 3023 (1982).

34 R. E. CARRAWAY, D. E. COCHRANE, J. B. LANSMAN, S. E. LEEMAN, B. M. PATERSON, and H. J. WELCH, Neurotensin stimulates exocytotic histamine secretion from rat mast cells and elevates plasma histamine levels. *J. Physiol.* **323**, 403–414 (1982).

35. D. E. COCHRANE, C. EMIGH, G LEVINE, R. E. CARRAWAY, and S. E. LEEMAN, Neurotensin alters cutaneous vascular permeability and stimulates histamine release from isolated skin. *Ann. N.Y. Acad. Sci* **400**, 396–397 (1982).

36 D. E. COCHRANE, W. BOUCHER, and P. BIBB, Neurotensin stimulates histamine release in *in vitro* skin blisters: An effect inhibited by cromolyn or somatostatin. *Int. Arch Allergy Appl. Immunol.* **80**, 225–230 (1986).

37 R KEROUAC, S. ST PIERRE, and F. PIOUX, Participation of mast cell 5-hydroxytryptamine in the vasoconstrictor effect of neurotensin in the rat perfused hindquarter. *Life Sci.* **34**, 947–959 (1984).

38 F. RIOUX, R. KEROUAC, and S. ST PIERRE, Release of mast cell mediators, vasoconstriction and edema in the isolated, perfused head of the rat following intracarotid infusion of neurotensin. *Neuropeptides* **6**, 1–12 (1985).

39. P. J. MANBERG, C. B. NEMEROFF, L. L. IVERSEN, M. M. ROSSER, J. S. KIZER, and A. J. PRANGER, Human brain distribution of neurotensin in normals, schizophrenics, and Huntington's choreics. *Ann. N.Y. Acad. Sci.* **400**, 354–367 (1982).

40. E. WIEDERLOV, I. H. LINDSTROM, G. BESEV, P. J. MANBERG, C. B. NEMEROFF, G. R. BRESSE, J. S. KIZER, and A. J. PRANGE, Subnormal CSF levels of neurotensin in a subgroup of schizophrenics and normalization after neuroleptic treatment. *Ann. N.Y. Acad. Sci.* **400**, 418–419 (1982).

41. K. MURAKI, Y. NISHI, H. OKAHATA, M. ARAI, H. YAMADA, S. PUJITA, Y. MIYACHI, K. UEDA, S. YAMAWAKI, and H. YAJIMA, Neurotensin-like immunoreactivity (NTLI) concentration in the cerebrospinal fluid of children and its alteration in a febrile aseptic meningitis. *Life Sci.* **40**, 1365–1370 (1987).

42. M. OTSHI, J. ISHIKO, C. INAGAKE, and S. TAKAORI, Release of histamine and adrenaline *in vivo* following intravenous administration of neurotensin. *Life Sci.* **32**, 2231–2239 (1983).

43. A. DUPONT and Y. MERAND, Enzyme inactivation of neurotensin by hypothalamic and brain extracts of the rats. *Life Sci.* **22**, 1623–1630 (1978).

44. R. J. BODNAR, M. M. WALLACE, G. NILAVER, and E. A. ZIMMERMAN, The effects of centrally administered antisera to neurotensin and related peptides upon nociception and related behaviors. *Ann. N.Y. Acad. Sci.* **400**, 244–258 (1982).

45. G. BISSETTE, D. LUTTINGER, G. A. MASON, D. E. HERNANDEZ, and P. T. LOOSEN, Neurotensin and thermoregulation. *Ann. N.Y. Acad. Sci.* **400**, 268–282 (1982).

46. L. G. COCKERHAM, E. L. PAUTLER, R. E. CARRAWAY, D. E. COCHRANE, and J. D. HAMPTON, Effect of disodium cromoglycate (DSCG) and antihistamines on postirradiation cerebral blood flow and plasma levels of histamine and neurotensin. *Fundam. Appl. Toxicol.* **10**, 233–242 (1988).